

MODIS land team



use of IKONOS data

High Spatial Resolution Commercial Imagery Workshop

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Greenbelt, Maryland

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Outline

- **Overview of MODIS Land team validation activity**
- **The EOS Land Validation Core Sites**
- **Early results using IKONOS data**

SAFARI 2000 & others

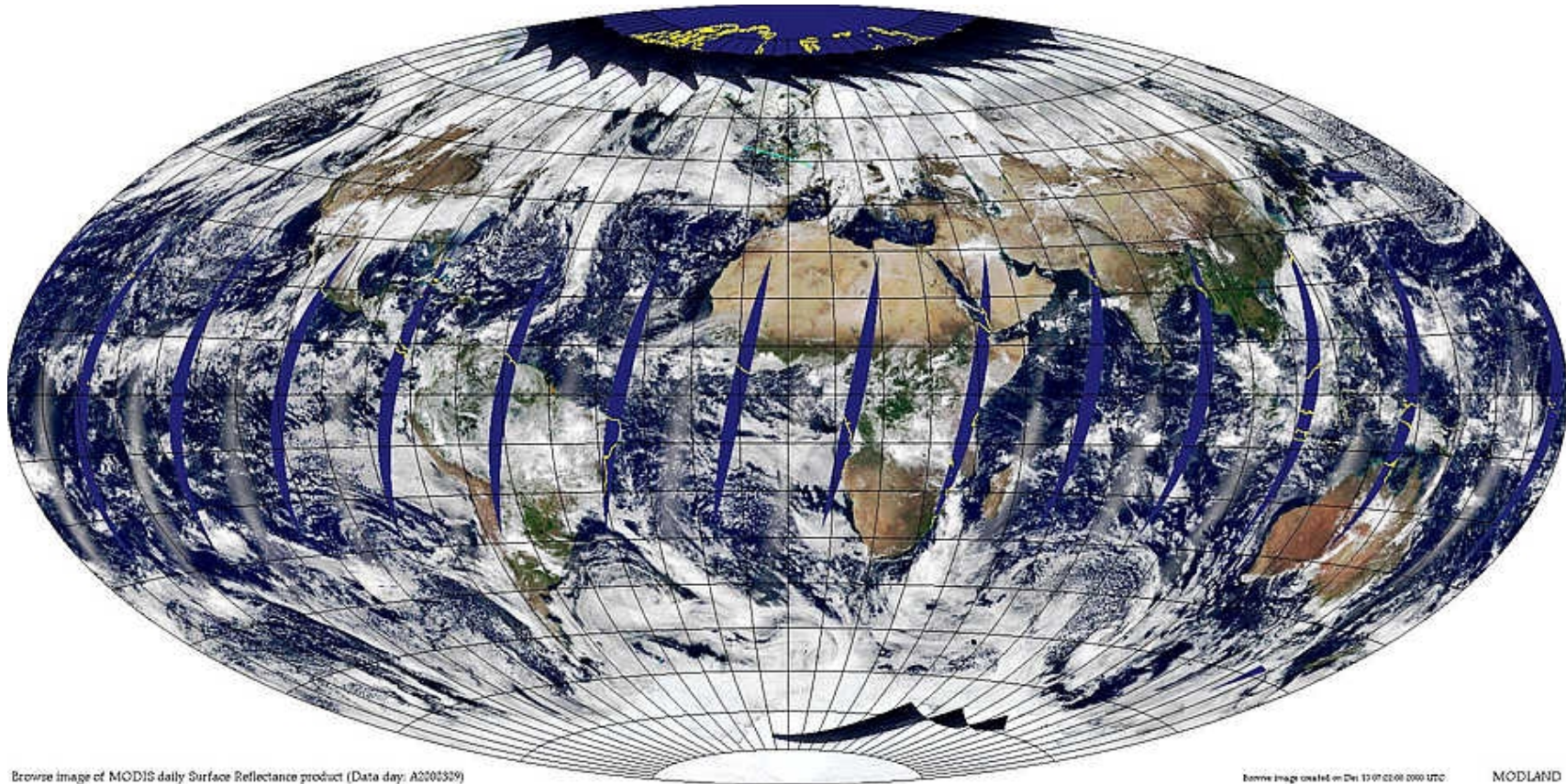


***MODerate Resolution Imaging
Spectroradiometer (MODIS)
on board Terra launched 12/19/99***





MODIS: ***near global coverage daily***



Atmospherically corrected land surface reflectance, 11/05/00
[***http://edcdaac.usgs.gov/modis/dataproduct.html***](http://edcdaac.usgs.gov/modis/dataproduct.html)

MODIS Land Products* / NASA Earth Science Enterprise Research Themes

- *Energy Balance Product Suite*
 - Surface Reflectance
 - Land Surface Temperature
 - BRDF/Albedo
 - Snow Cover
- *Vegetation Parameters Suite*
 - Vegetation Indices
 - LAI/FPAR
 - NPP/PSN
- *Land Cover Land Use Suite*
 - Land Cover
 - Vegetation Continuous Fields
 - Vegetation Cover Change
 - Fire and Burned Area

**Global Water Cycle and Energy
Balance**

**Biology and Biogeochemistry
of Ecosystems and the Global
Carbon Cycle**

**Land Cover and Land Use
Change**

**Atmospheric Chemistry and
Aerosols**

***Applications
Education
Assessments***



Validation:



*“the process of assessing
by independent means
the quality of the data
products derived from the
system outputs”*

- CEOS

MODLAND validation home page

<http://modarch.gsfc.nasa.gov/MODIS/LAND/VAL>

Morisette, Privette, & Justice



Why we need to validate MODIS land products

- **Good science and resource management require understanding of product accuracy/uncertainty**
- **Explicit statements of uncertainty fosters an informed user community and improved use of data**
- **International environmental protocols and agreements imply findings will be independently evaluated and possibly challenged**
- **As more, and similar, global products are produced by CEOS members, inter-use will require characterization of each product's uncertainty**



MODLAND Validation

general operating principles

- **the ultimate objective is to characterize products' uncertainty**
- **utilize independent data with relatively high accuracy and global consistency**
- **recognize limited resources for both data collection and analysis**
- **capitalize on the concept that imagery and field data sets can often be used to validate more than one product**



Implications of operating principles

- **Partnerships with**
 - other field programs (e.g., LTERs)
 - science networks (e.g. AERONET, Fluxnet, & **SDP**)
 - international research efforts (LBA, SAFARI 2000)
 - International planning
(CEOS working group on Calibration and Validation)
- **Development of a set of core validation sites**
 - **globally consistent data sets**
 - provide a foundation for a network that can grow toward global representation.
- **Serve a wide range of investigators interested in landscape characterization**



Three main components for each product

- **Instruments and imagery needed for reference data**
- **Sites where these data will be collected**
- **Protocol for collecting data and conducting correlative analysis**
 - *instruments are generally product specific*
 - *imagery needs are consistent across products*

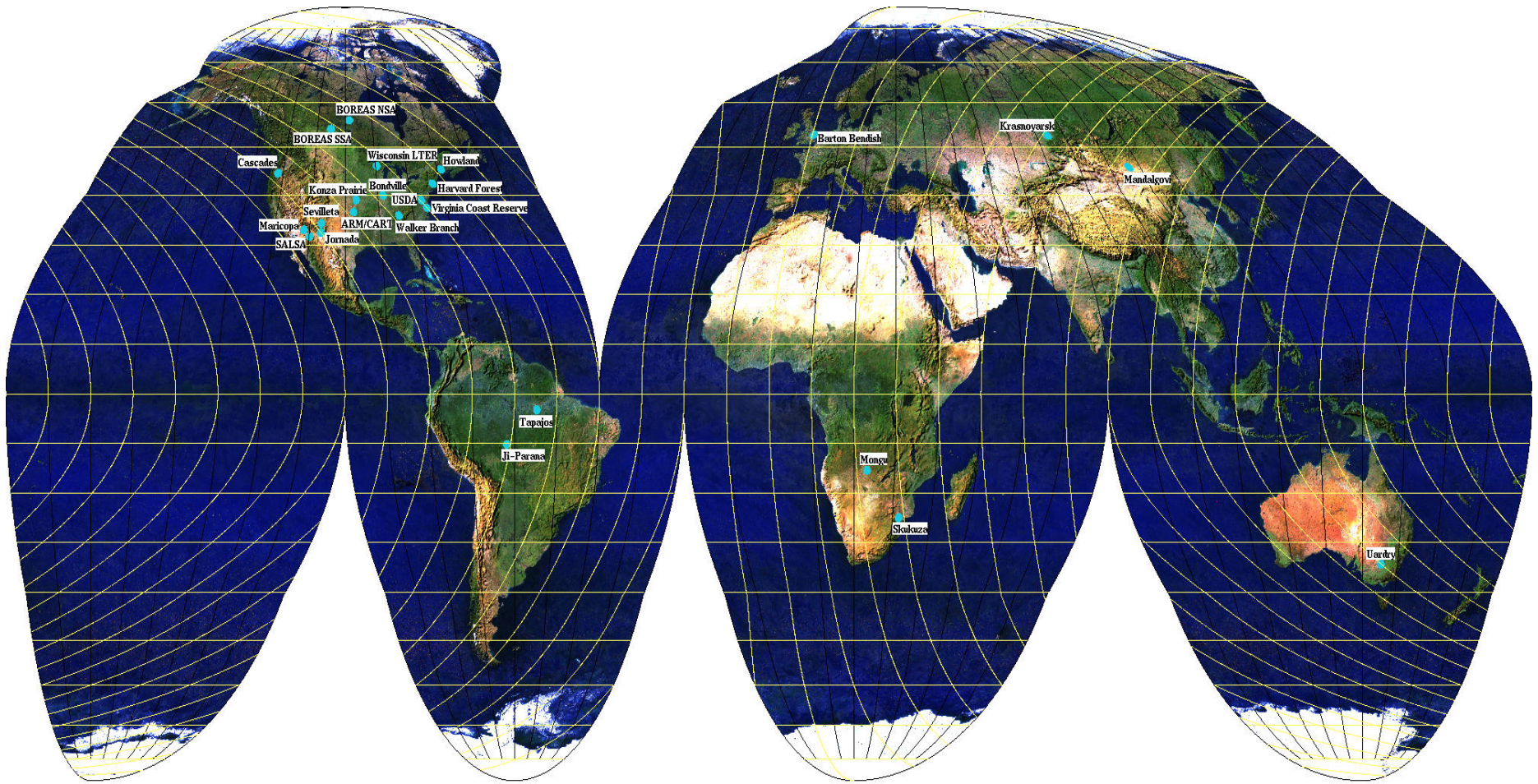


Why MODLAND uses IKONOS data for validation

- **High spatial resolution can help associate field measurements to other satellite data
(ETM+ \longrightarrow MODIS)**
- **High geometric accuracy**
- **Available globally and globally consistent**



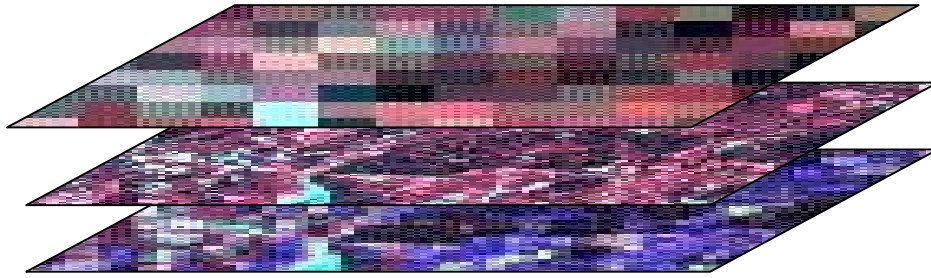
EOS Land Validation Core Sites



EOS Land validation core sites - Goode homolosine projection - Black grid: 10 deg. graticule - Yellow grid: MODLAND L3 tiles

Jacques Desclotres (MODLAND/LDOPE) - May 1999

EOS Land Validation Core Sites



Satellite imagery

MODIS Subsets (EDC DAAC)

ETM+ (EDC DAAC)

ASTER data (EDC DAAC)

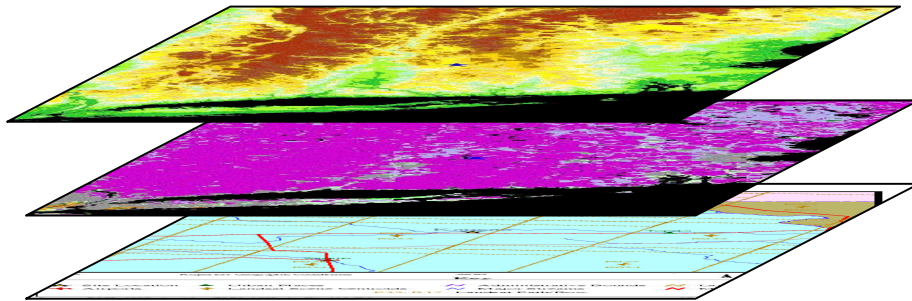
MISR Local Mode (Langley DAAC)

SeaWiFS Subsets (GSFC)

IKONOS (SDP/GLCF)

“GeoCover ’90s TM (SDP)

EO-1



Ancillary layers and background information such as existing

- elevation
- land cover
- reference layer

available through UMD ESIP – GLCF

Field and airborne data:

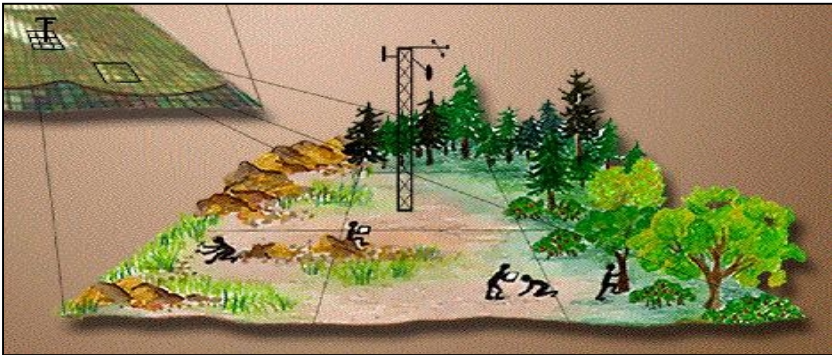
archive and access through
ORNL DAAC’s “Mercury System”

AERONET and FLUXNET data

Black: available for all Core Sites

Blue: available for some Core Sites,

Green: not currently available



Field data graphic courtesy of the BigFoot program



Spectral bands for imagery utilized by MODLAND validation

AVIRIS

(224 bands between 400 to 2500)

MAS/MASTER

(25 channels between 400 and 2500)

AVHRR

1 2

SeaWiFS

1 2 3 4 5 6 7 8

ASTER

1 2 3 4 5 6 7 8 9

IKONOS

1 2 3 4 Pan.

ETM+

1 2 3 4 Pan. 5 7

MQUALS

3 4 1 2

MODIS

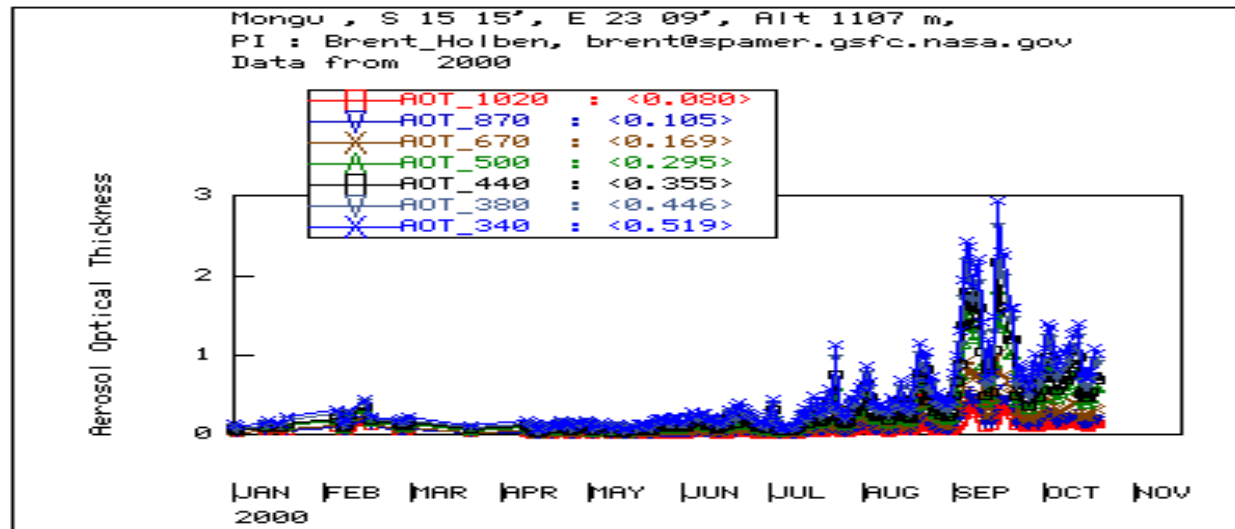
3 4 1 2 5 6 7

400 600 800 1000 1200 1400 1600 1800 2000 2200 2400

nanometers (nm)



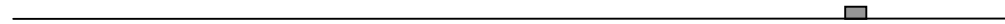
Acquisition frequency: example from *MONGU Core Site*



AERONET data



IKONOS



ASTER



ETM+



**MODIS 8-day
Surf. refl.subsets**



**SeaWiFS
(>100 subset for 2000)**



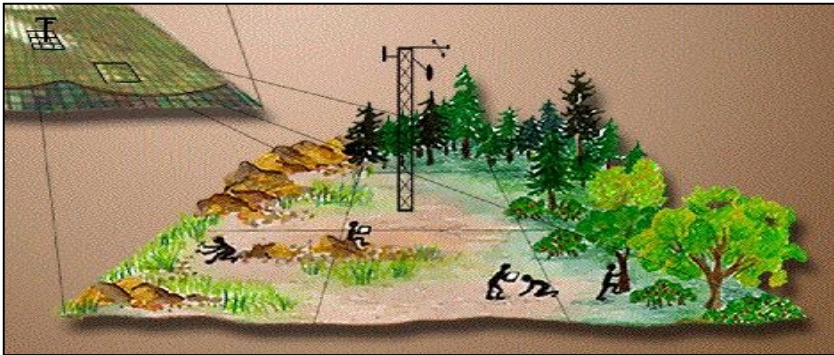
Core Site data summary

	ARM/CART	Barton Bendish	Bondville, IL	BOREAS, NSA	BERMS	Cascades LTER	Harvard Forest	Howland	Ji-Parana	Jornada LTER	Konza Prairie	Krasnoyarsk	Mandol gobi	Maricopa Ag.	Mongu	SALSA	Seville LTER	Skukuza	Tapajos	Uardry	USDA ARS	VCR	Walker Branch	Wisc. Park Falls
MODIS Subsets																								
SeaWiFS subsets																								
Ancillary report (CRESS)																								
Ancillary data (GLCF)																								
ETM+ (with # of acquisitions)			7	3			5			4	5	2	1		7		2		5		5			5
Ikonos		1-DEM	2		1	1	1		2	2	1			2		4				2				
Airborne (MQUALs or ER-2, both)																								
Global Land Cover Test Sites																								
GeoCover: 1990 TM data																								
Aeronet CIMEL (planned)																								
EO-1 coverage - planned																								
ASTER & MISR local mode - planned											1													

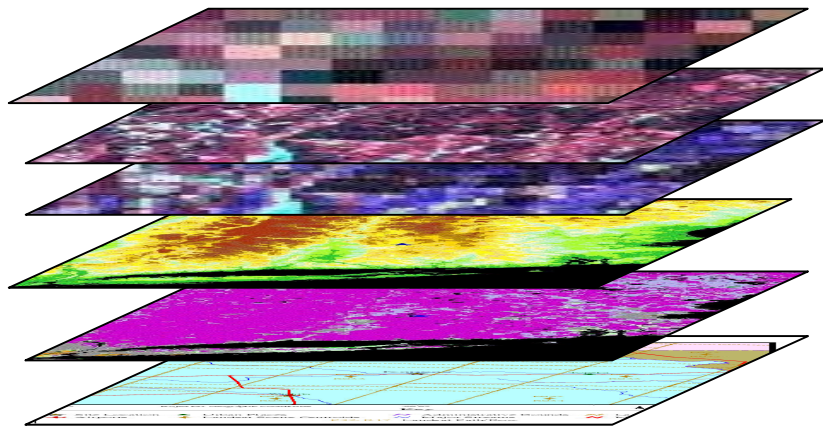
Morisette, Privette, & Justice



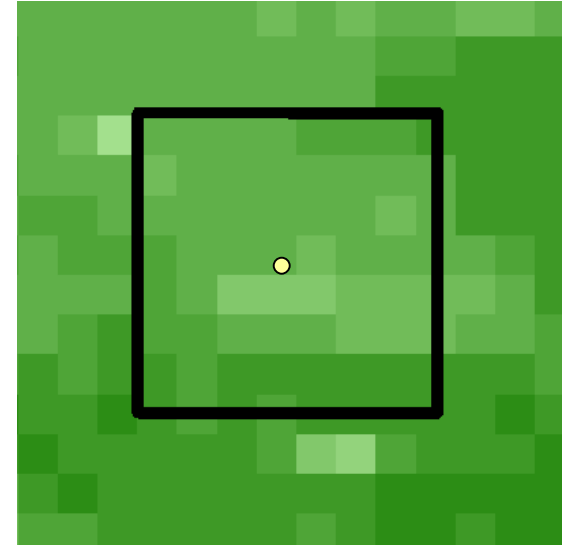
The scaling issue



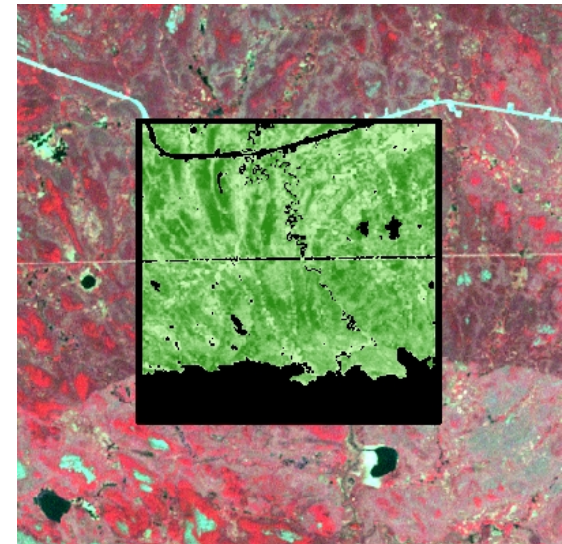
↓
Calibration



Aggregation
→

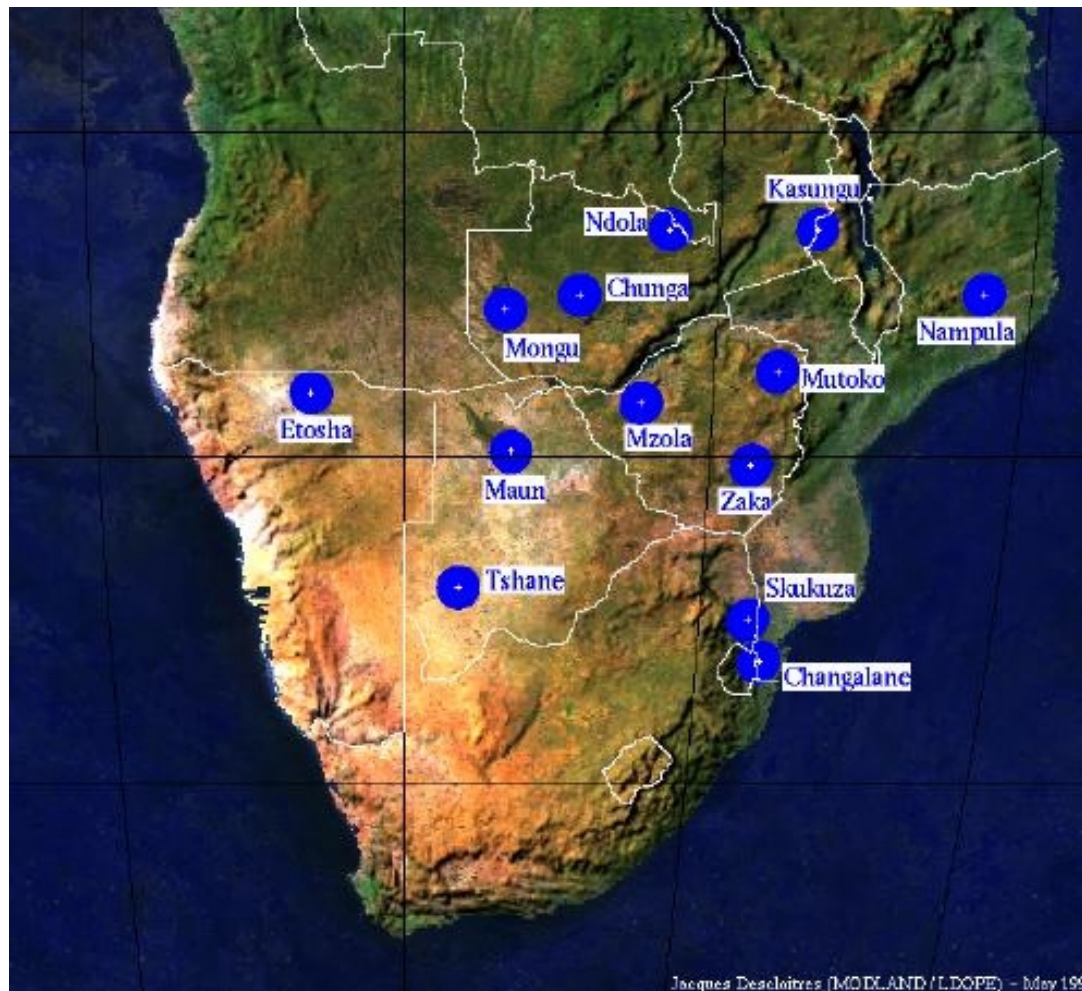


Correlation ↑





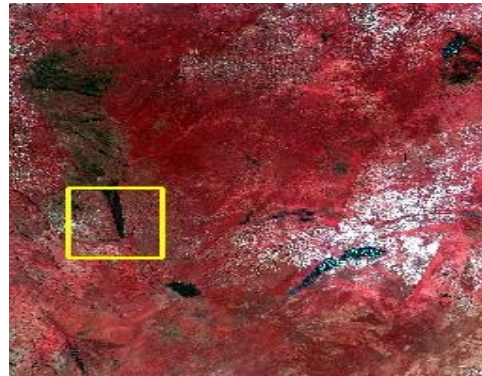
Southern Africa Fire and Atmosphere Research Initiative: SAFARI 2000



Jacques Desloires (MODLAND/LDOPE) - May 1999

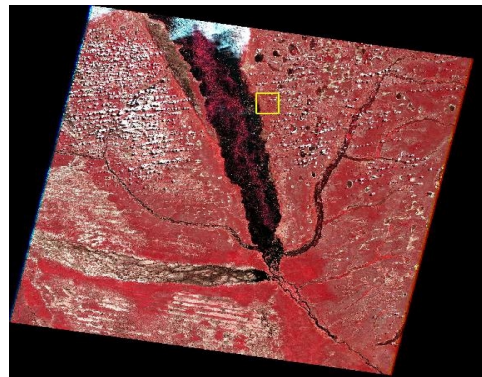


1200km



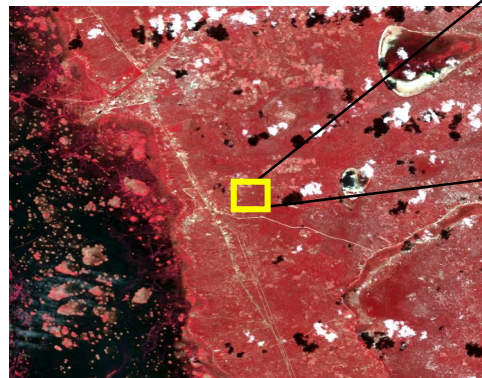
MODIS 1200x1200km² tile
yellow box indicates bounding
box for ETM+ scene below

~200km



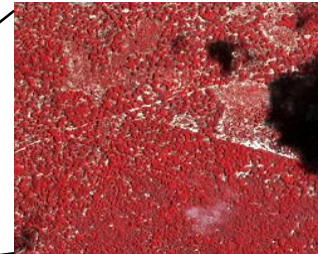
ETM+ scene
yellow box indicates bounding
box for IKONOS scene below

11km



IKONOS, close up

1 km

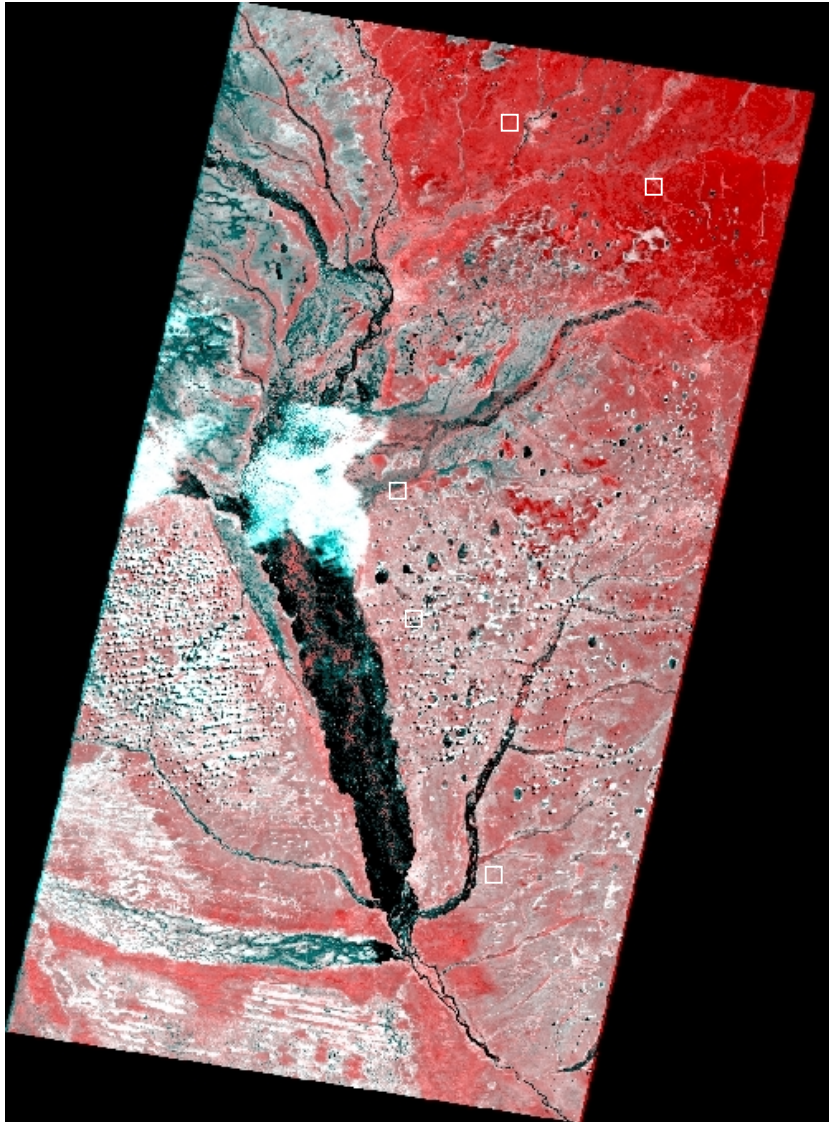


1 km



ETM+, close up

IKONOS use in Western Zambia to Map Tree Cover



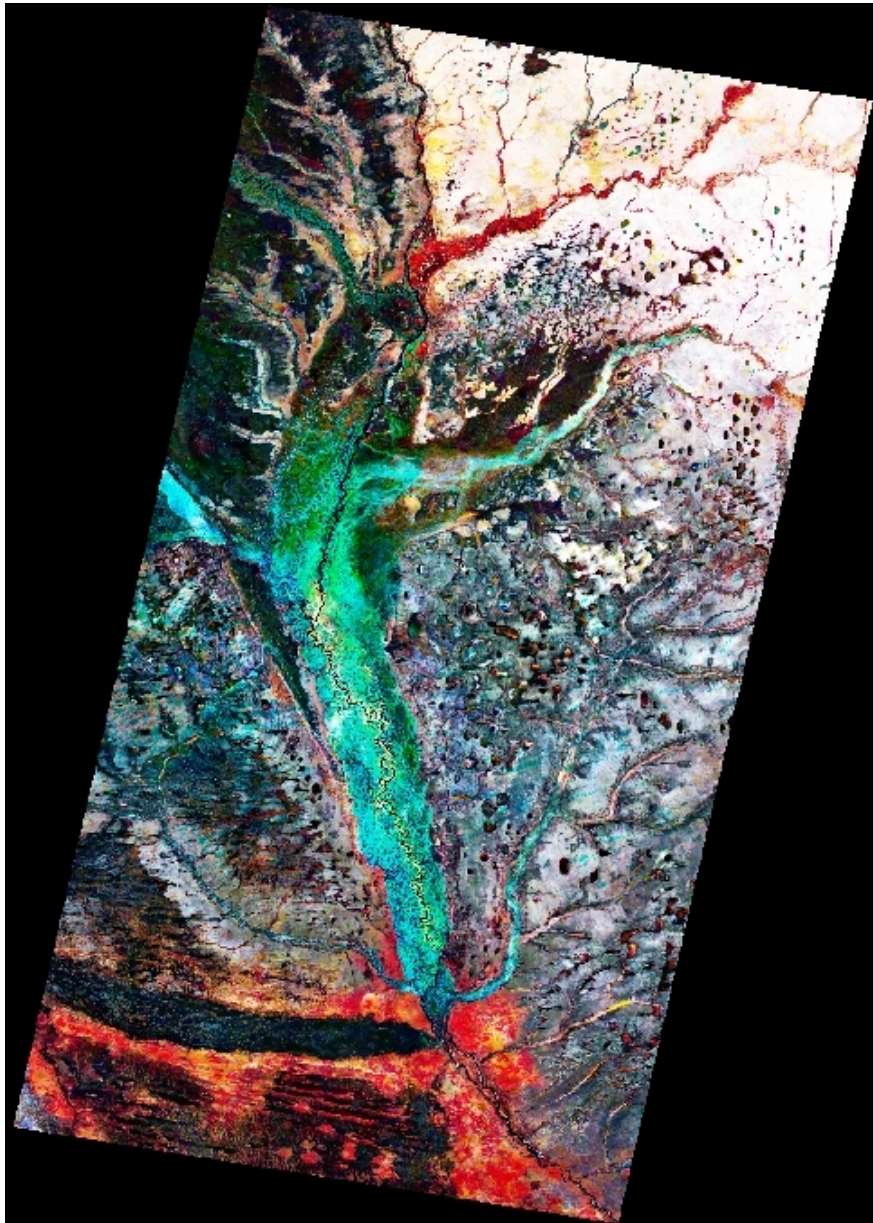
**Using IKONOS to “train”
ETM+ data**

**IKONOS acquisitions shown
as white squares**

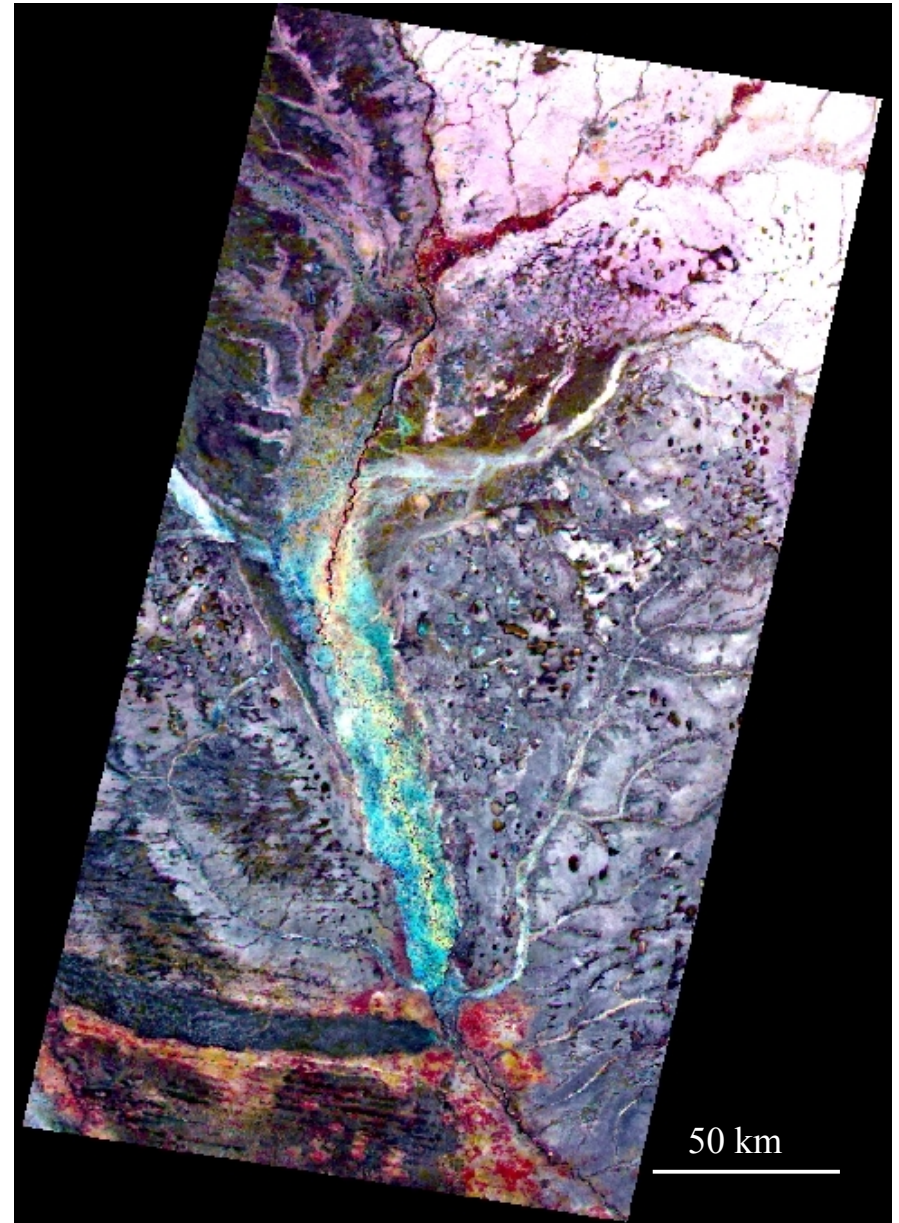
False Color composite for
Zambia
Landsat WRS 175/070-071,
April 4, 2000

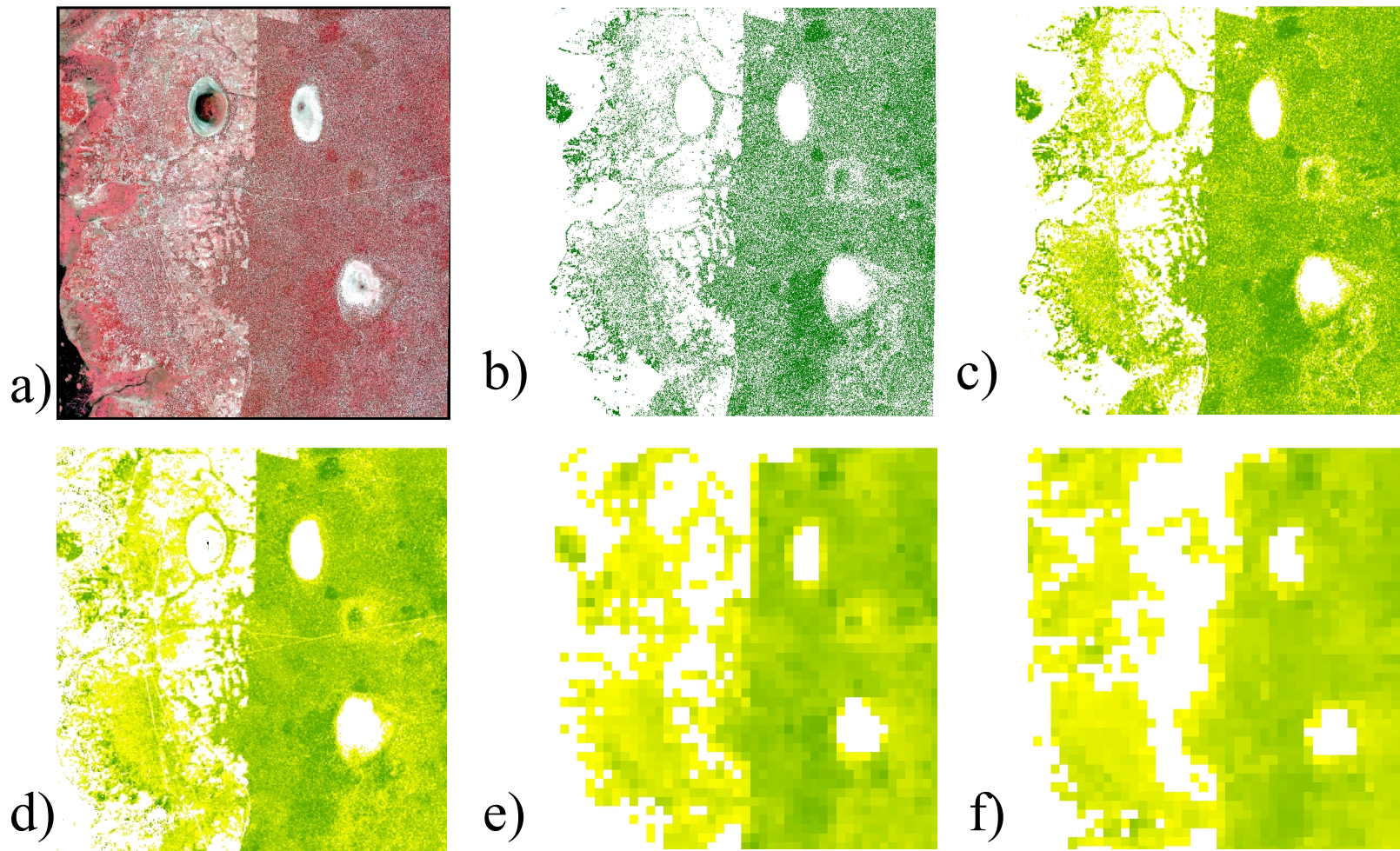
*from Hansen, Umd
With Townshend and Defries, UMd*

ETM+ NDVI composite,
red=April 4, green=June 29, blue=August 16,
2000

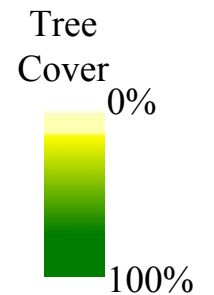


MODIS NDVI composite,
red=May 20, green=June 25, blue=July 27
2000

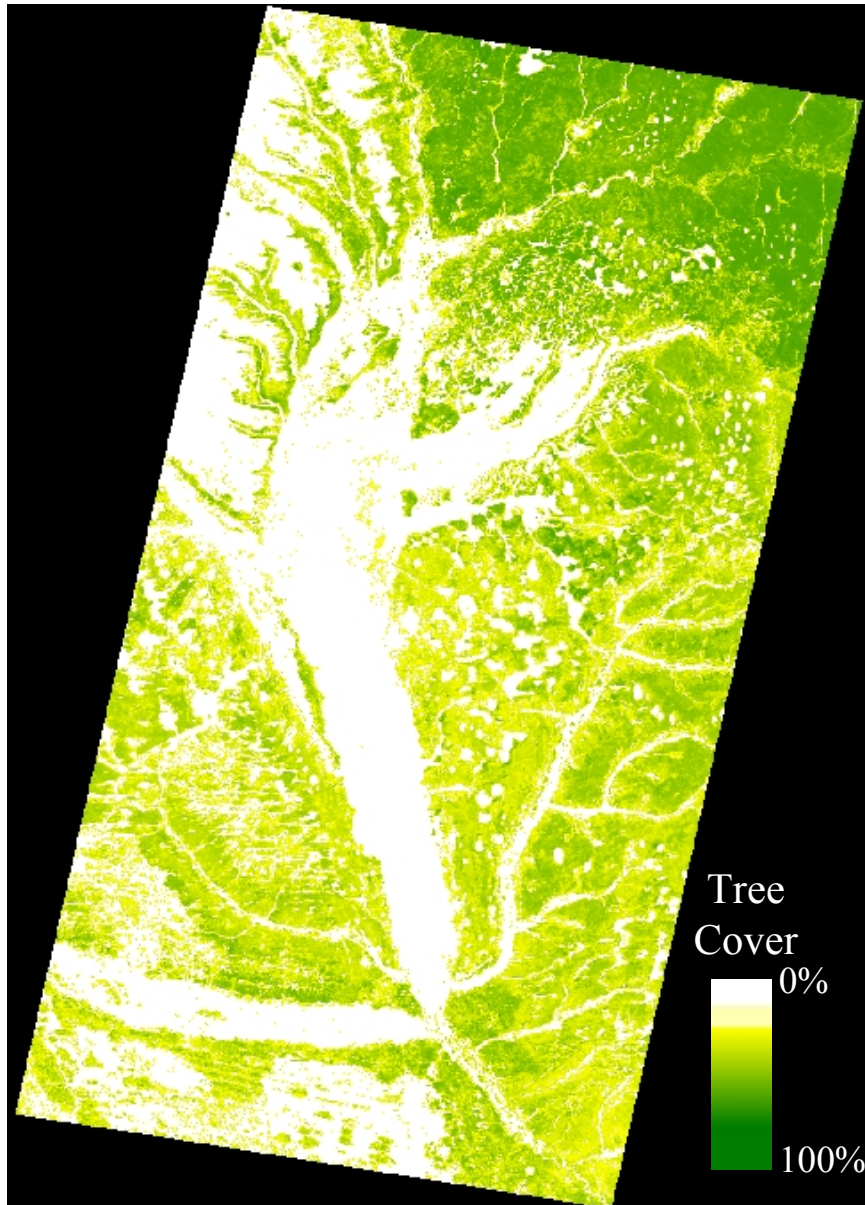




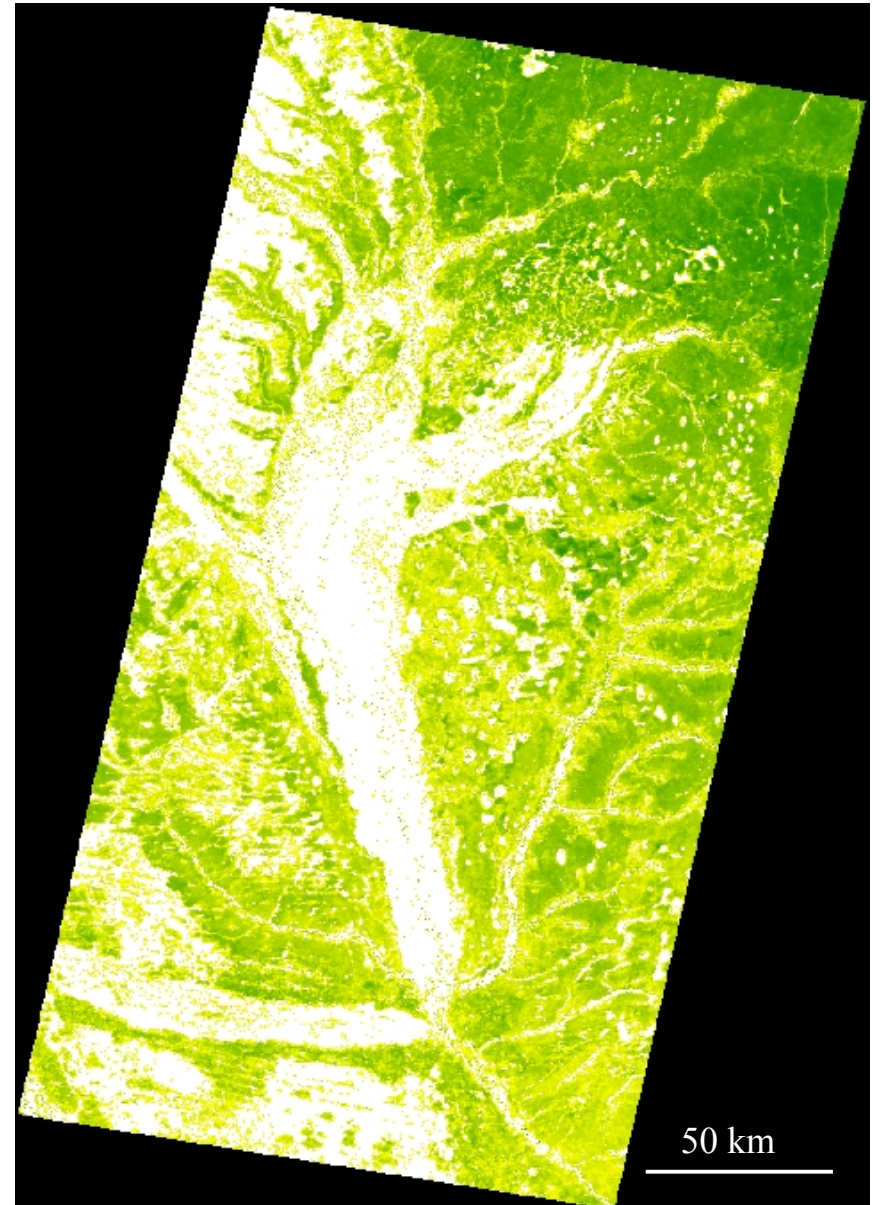
- 4 m IKONOS 4-3-2 combination, 11km by 11km,
- crown cover interpretation,
- aggregated continuous crown cover training at 30 meter resolution,
- ETM canopy cover derived from IKONOS training,
- result aggregated to 250 meter for MODIS validation use,
- MODIS predicted crown cover at 250 meter resolution



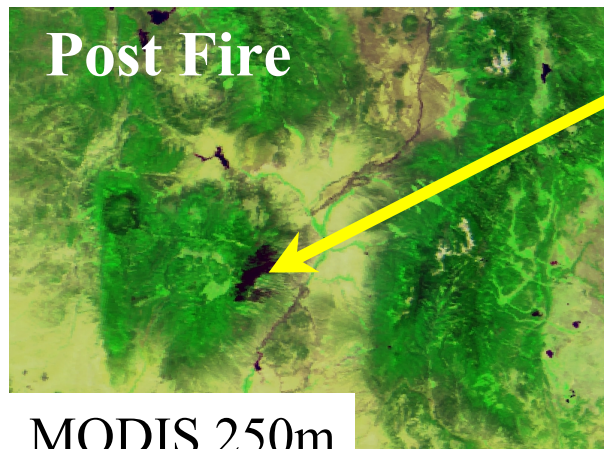
ETM+ crown cover
aggregated to 250 meters



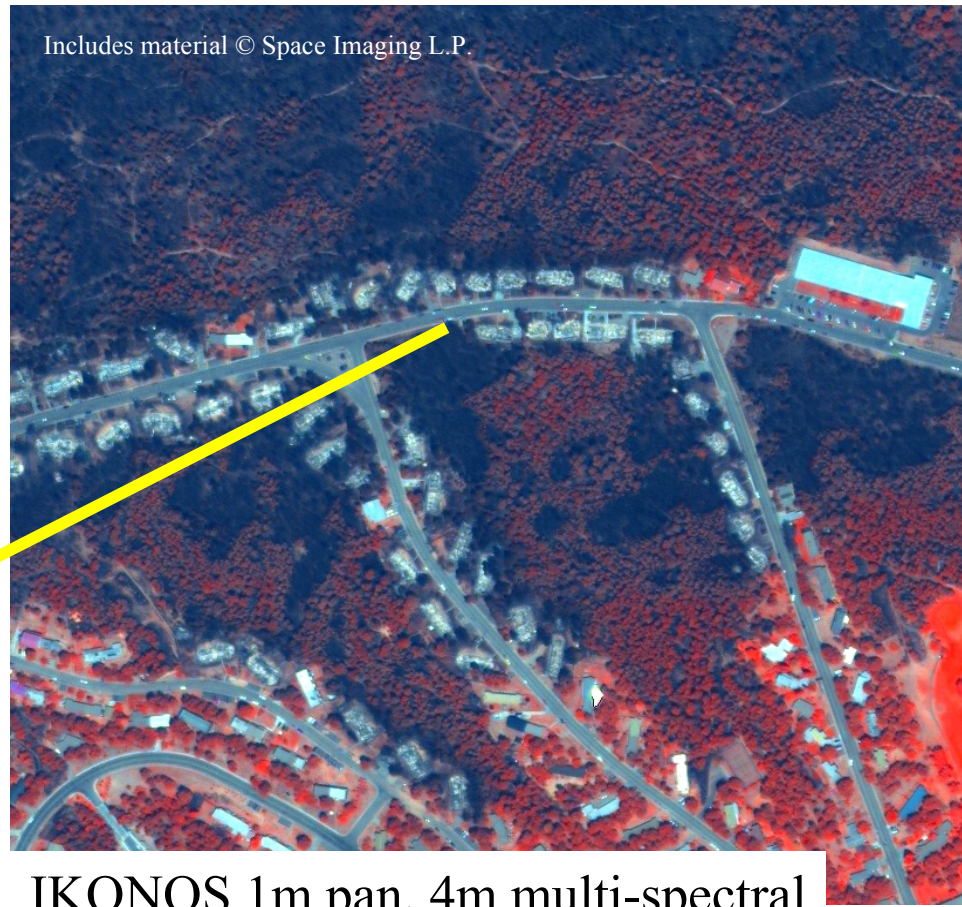
MODIS 250 meter predicted tree cover
using training taken from TM product



Cerro Grande (Los Alamos) Fire: MODIS Land Cover Change



MODIS 250m



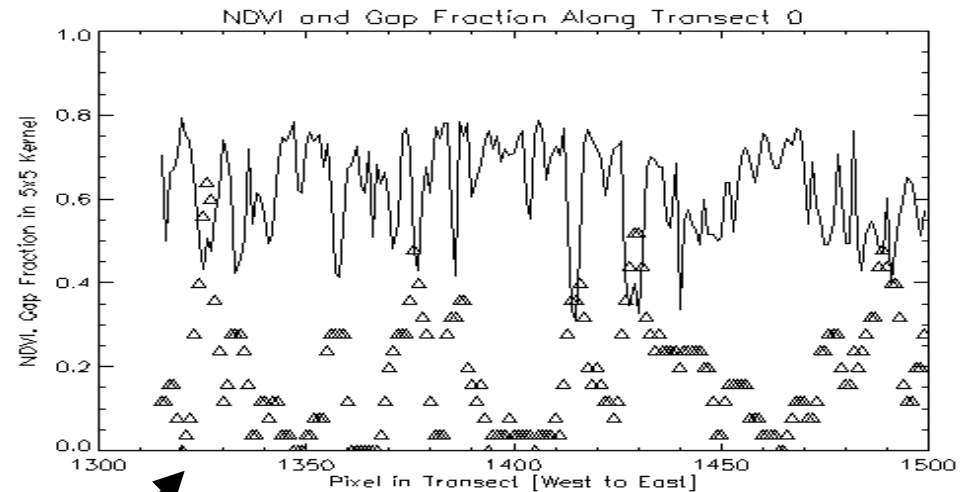
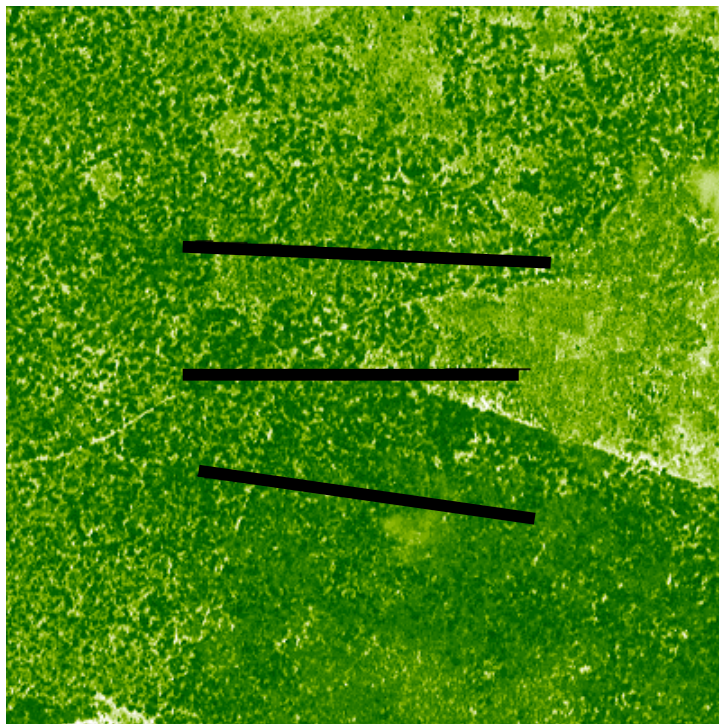
IKONOS 1m pan, 4m multi-spectral

IKONOS provides an important new perspective on land cover change to examine scaling and mixed pixel effects.



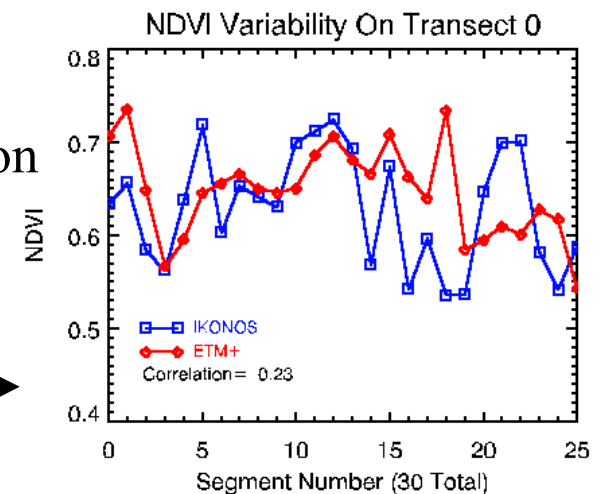
Transect Variability Across Forest Border: NDVI and Gaps

IKONOS NDVI 4 m/pixel



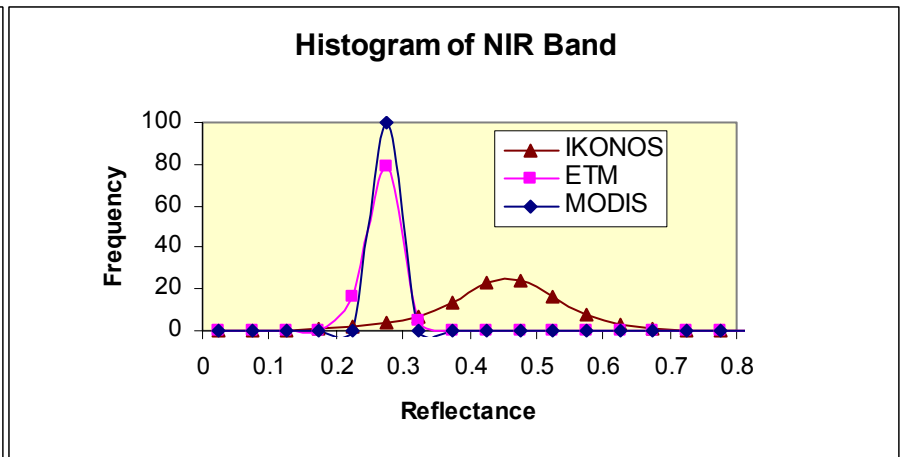
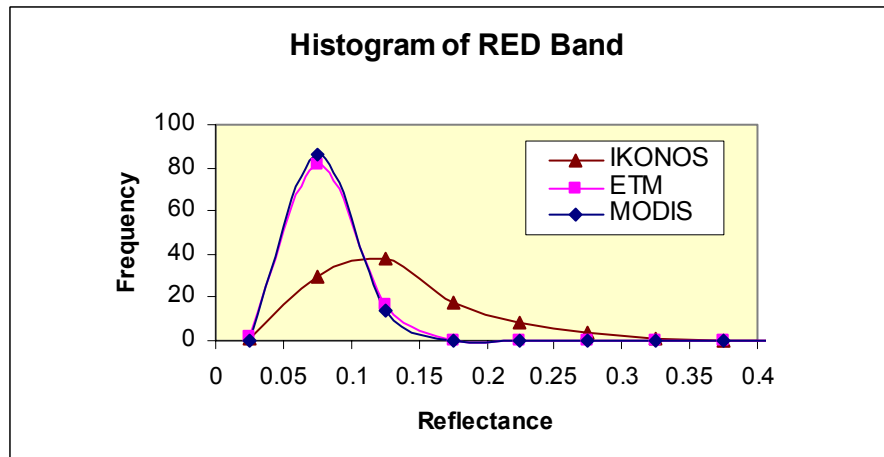
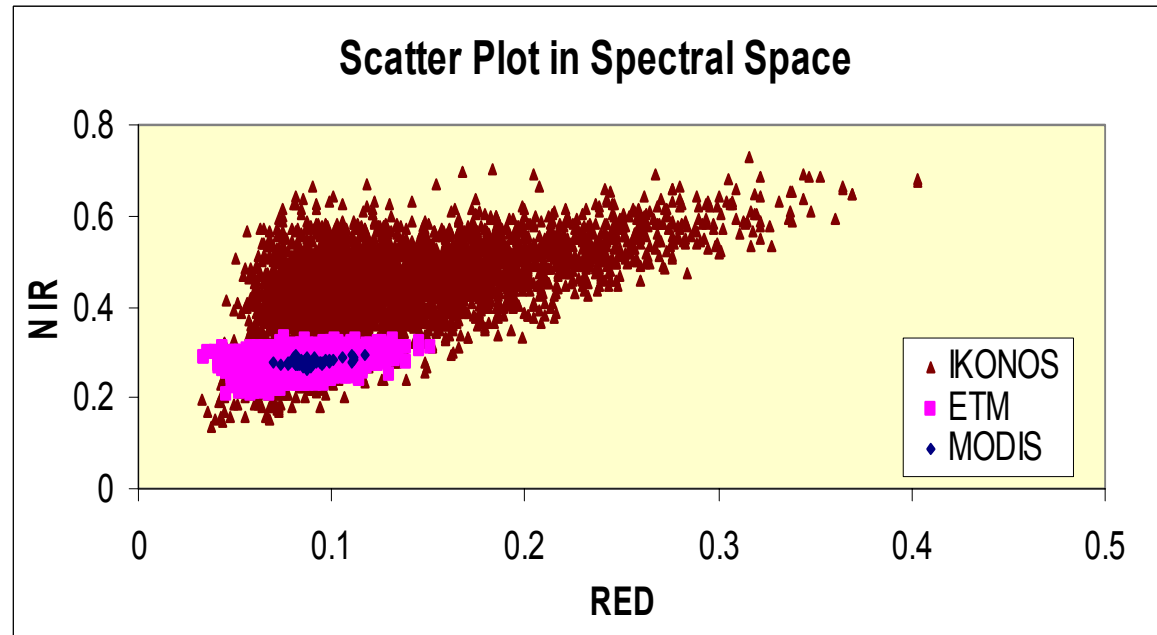
IKONOS:
NDVI vs gap fraction

IKONOS vs ETM+ 





Reflectance Comparisons



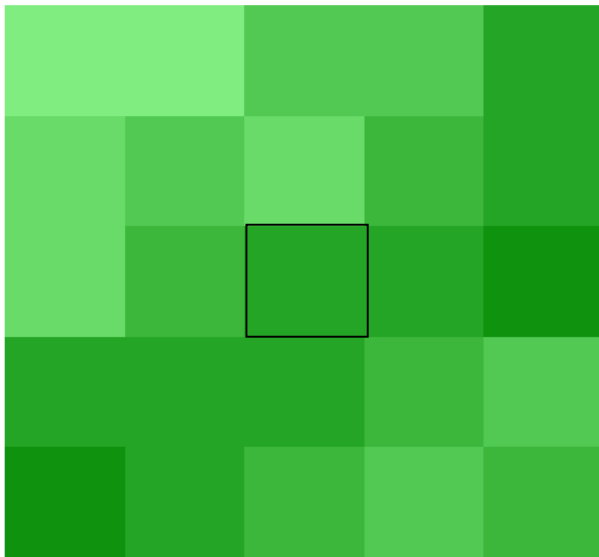
From Myneni et al, BU



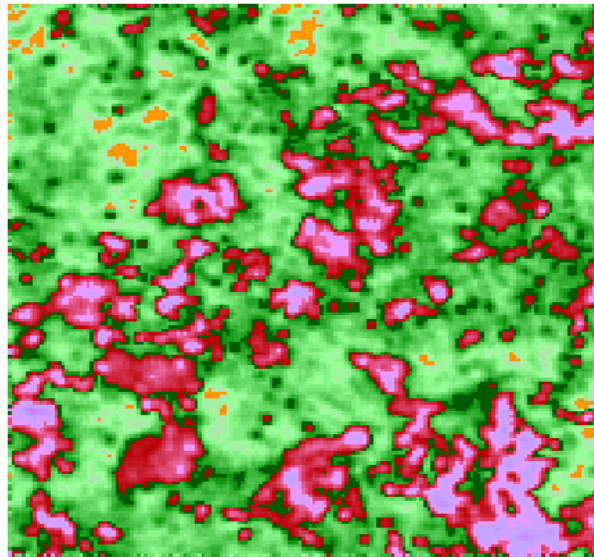
Leaf Area Index/FPAR

*BU/Myneni et al., LAI Map of a 5 KM Area, from
SAFARI 2000*

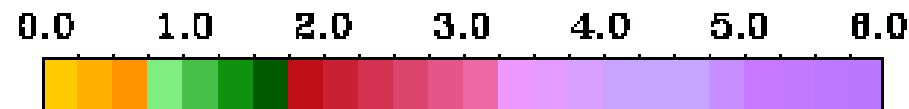
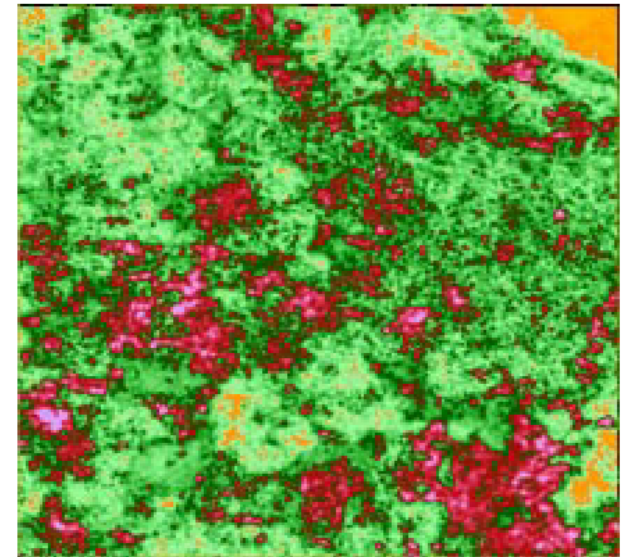
MODIS Retrievals, Apr. 3, 2000



ETM Retrievals, Apr.3, 2000



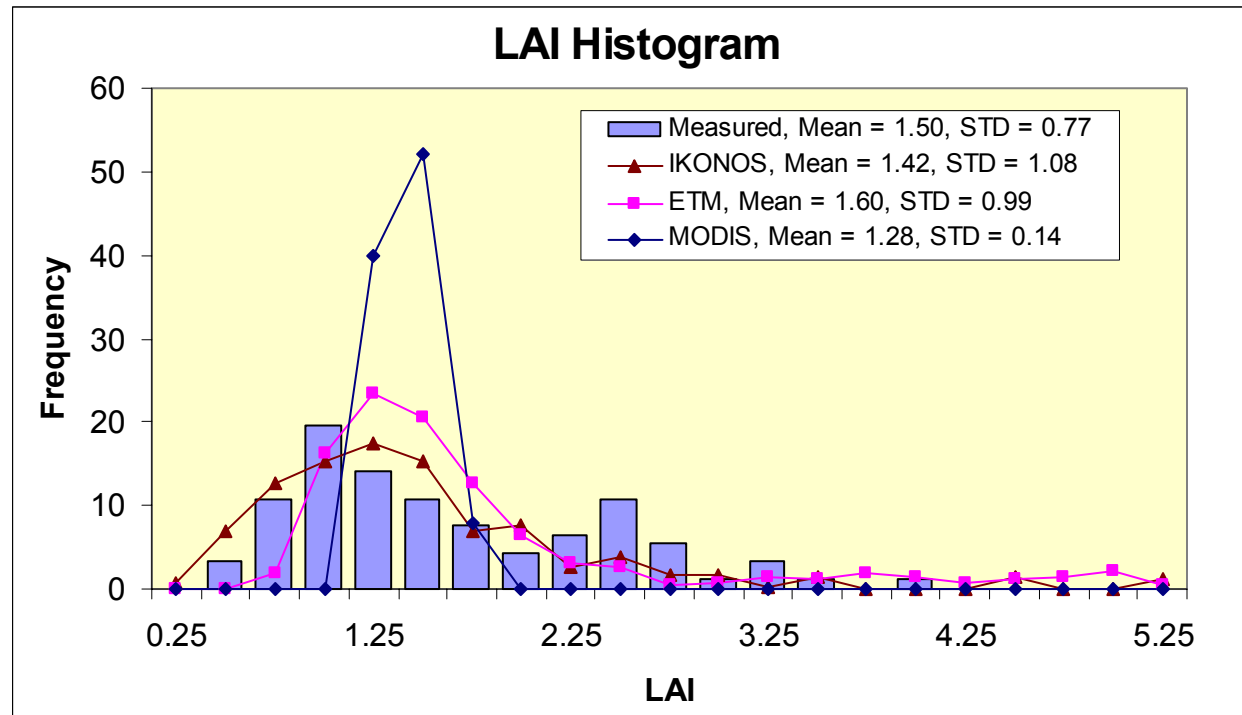
IKONOS Retrievals, Mar. 30,2000



LAI Maps: Myneni



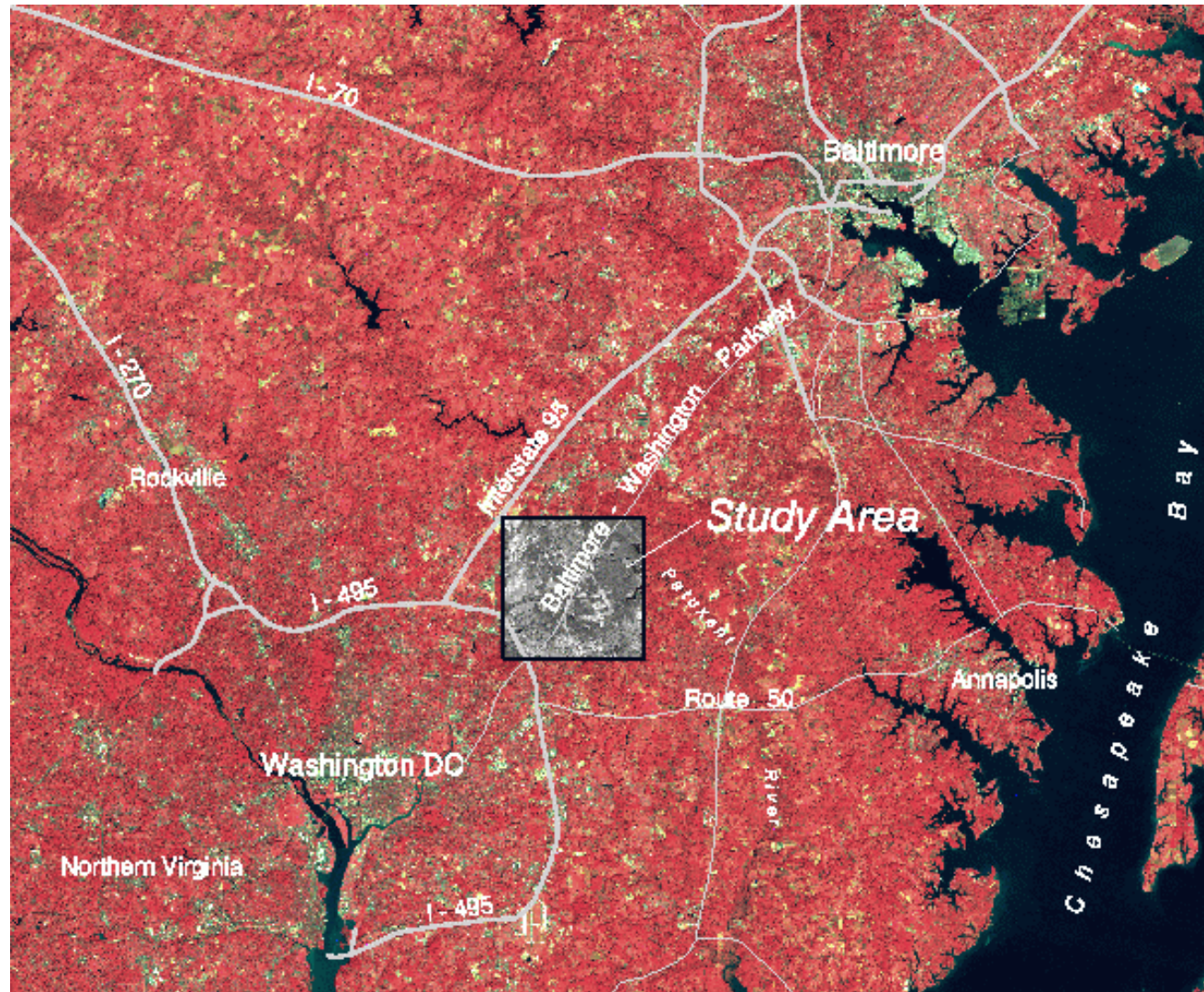
Histogram of Retrieved LAI



From Myneni et al, BU

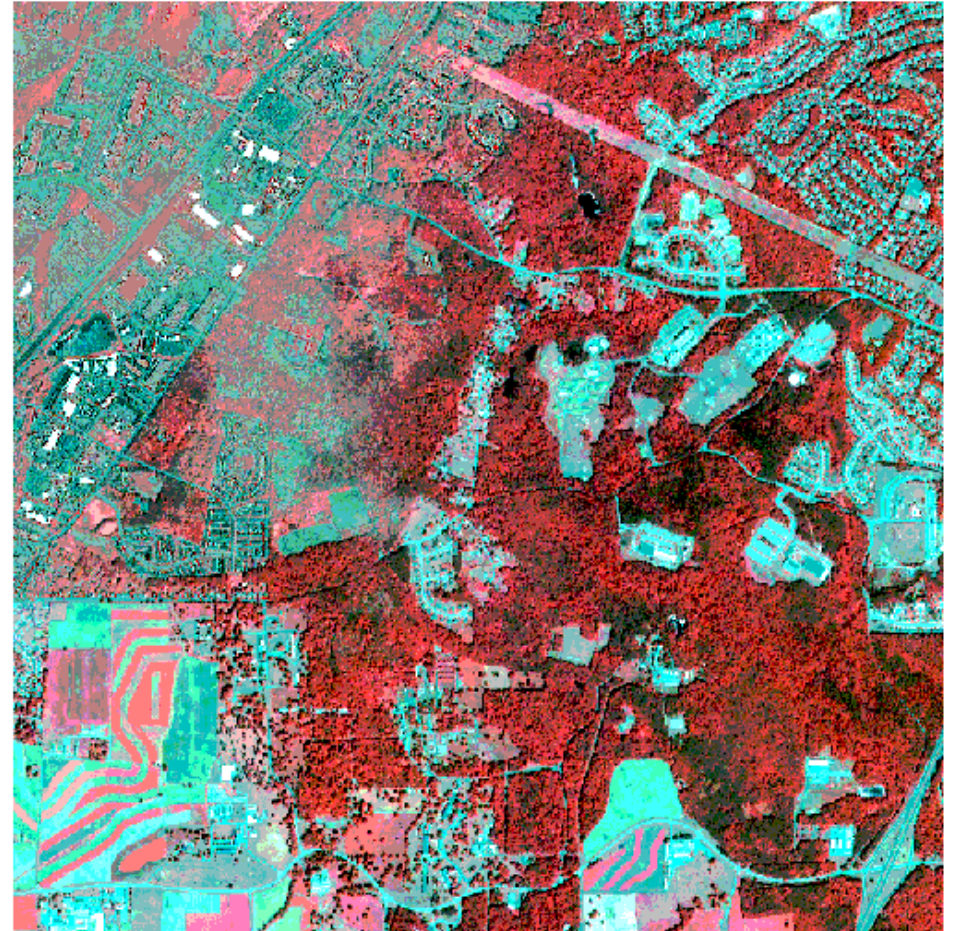


USDA BARC: EOS Land Validation Core Site





IKONOS imagery of USDA/BARC, June 3, 2000

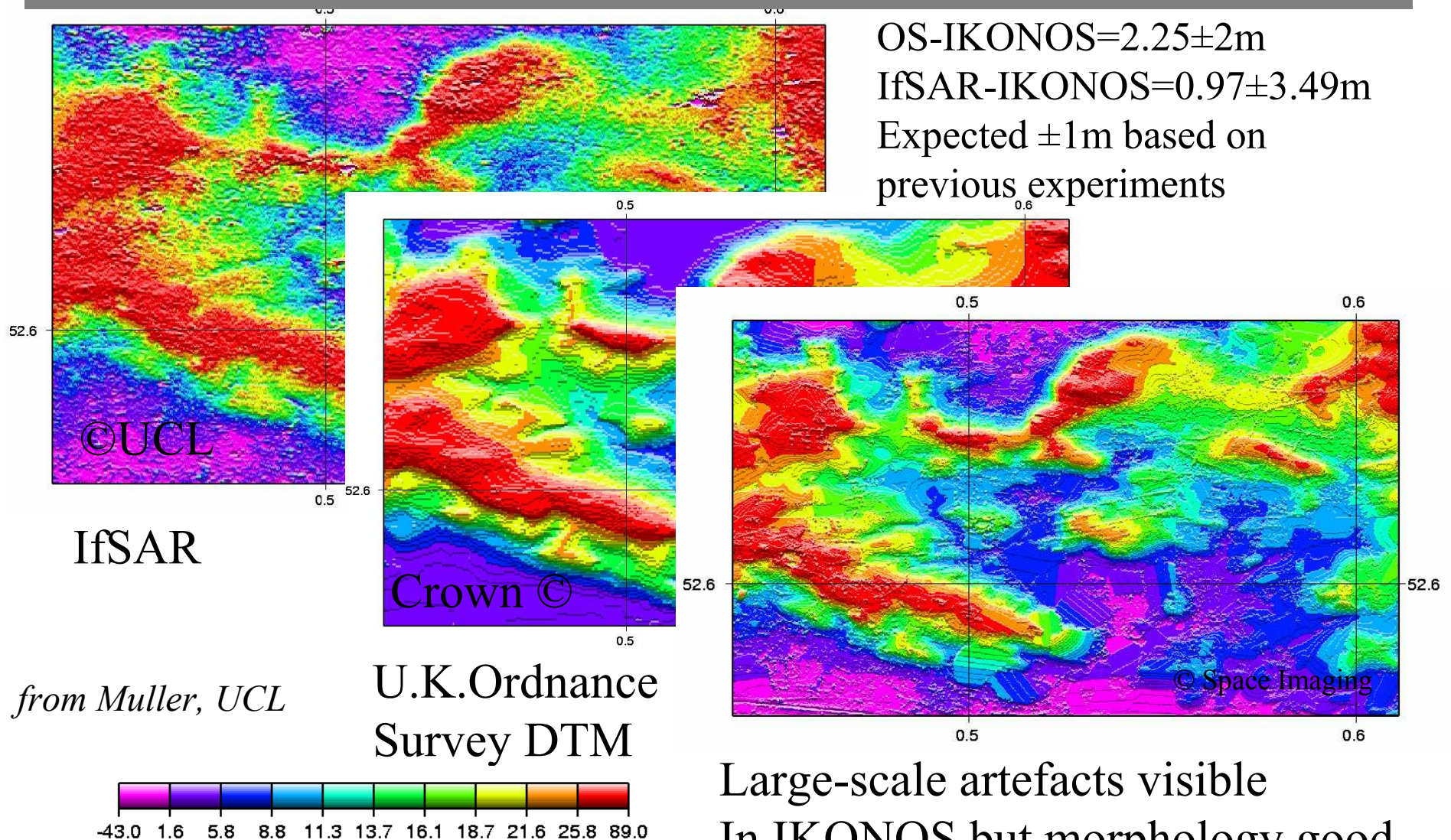


from Liang, UMd

Morisette, Privette, & Justice

Includes material © Space Imaging L.P.

Stereo IKONOS for landscape 3D modelling for BRDF simulation: DEM intercomparison at 30m





Stereo IKONOS for landscape 3D modelling for BRDF simulation

- 3D landscape models will be used to simulate a BRDF at aircraft and satellite resolutions given field measurements of BRDF at the canopy level.
- 3D landscape models combined with orthorectified provide a much less ambiguous way to classify land cover types.
- 3D landscape models can be used to measure the Aerodynamic Surface Roughness Length

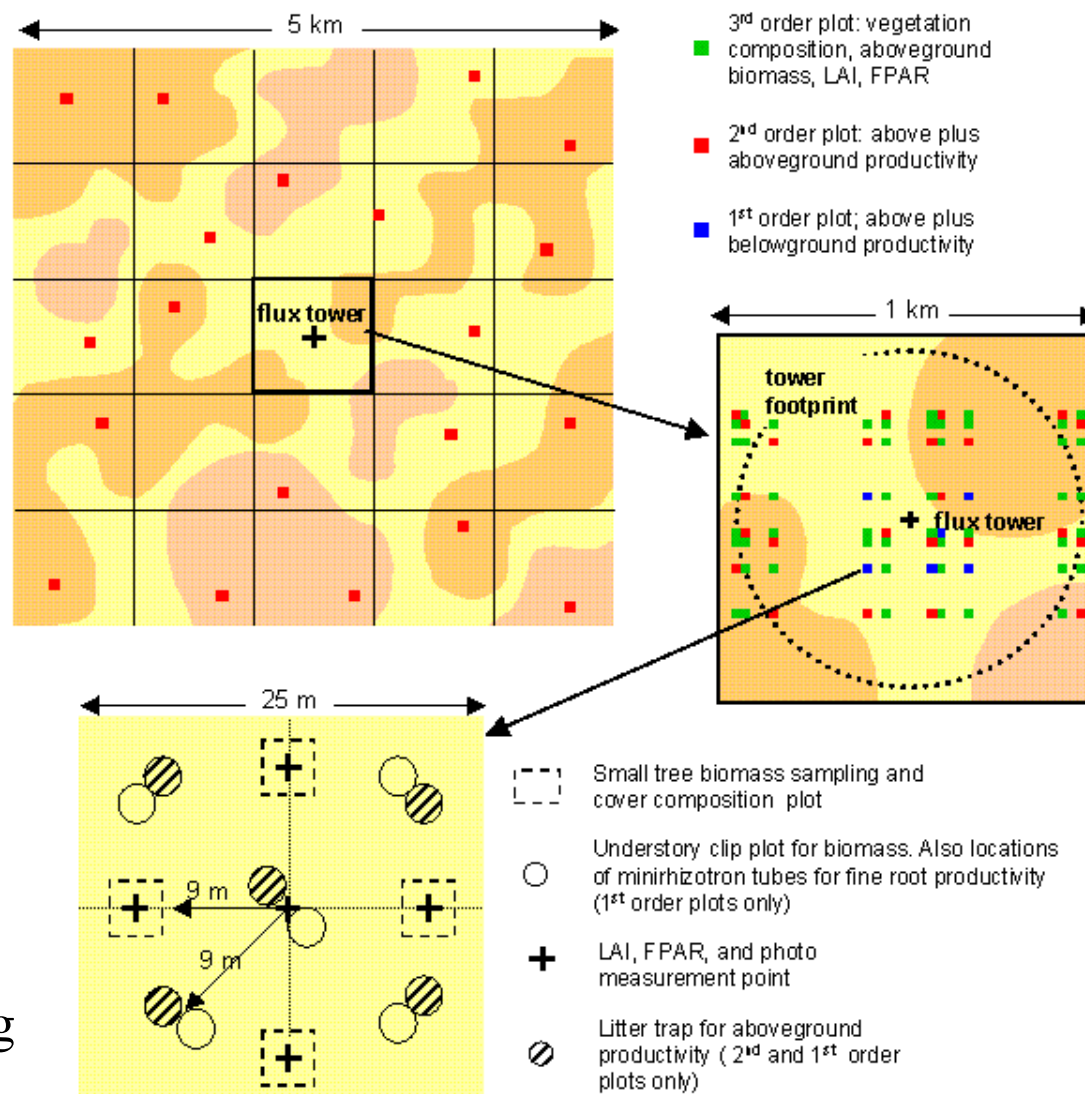


- **Currently:**
 - “the most important intermediate step between field data and Landsat.”
 - using IKONOS to georeference the ETM+.
- **Plans:**
 - Investigate how adding IKONOS into the data analysis improves what can be done using ETM+ alone



Field-Based Sampling Design

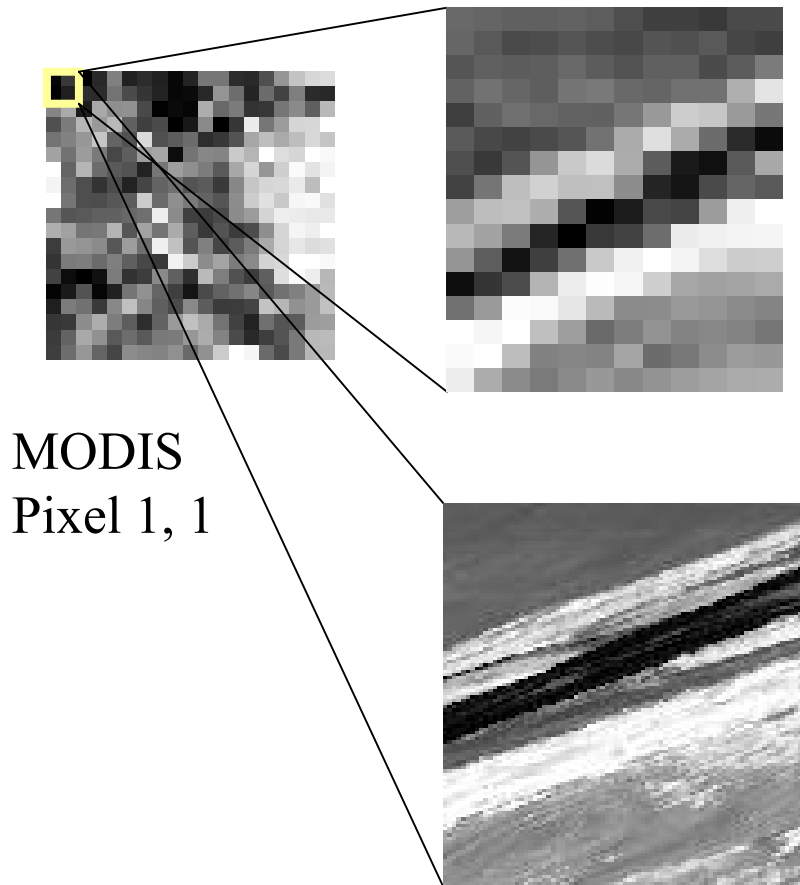
IKONOS to help with
sub-ETM- scale sampling



For forest plots, a prism sweep for stem biomass will be made from the plot center



Comparison at Multiple-scales



ETM+
14, 16
n=224

Considering all three as variable and subject to errors, consider MODIS pixel relative to the *distribution* from the higher resolution data

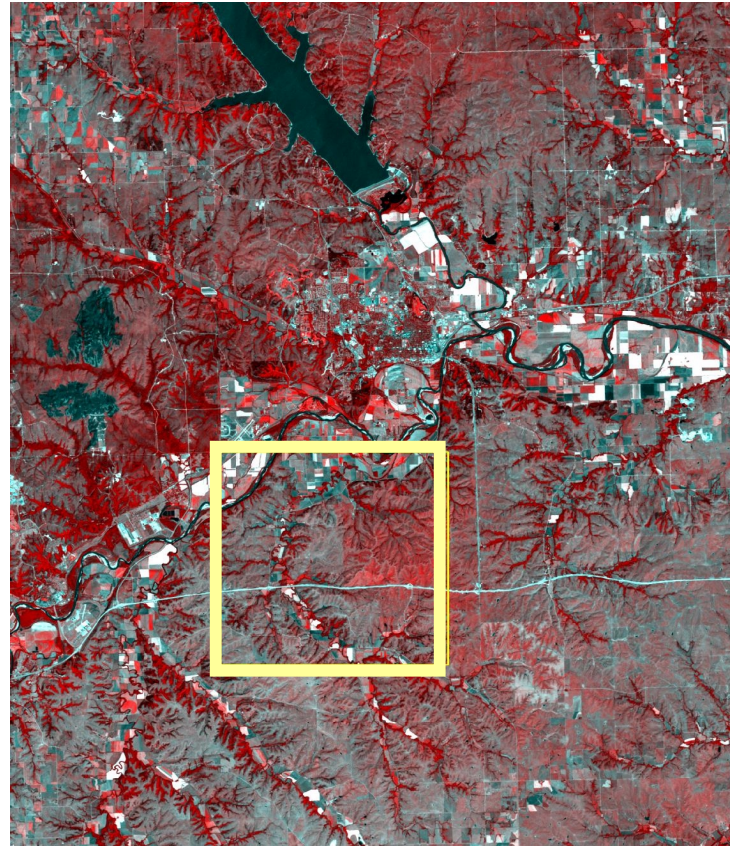
IKONOS
116, 120
n=13,920



IKONOS boundary on MODIS 500m and ETM+



MODIS
8-day composite



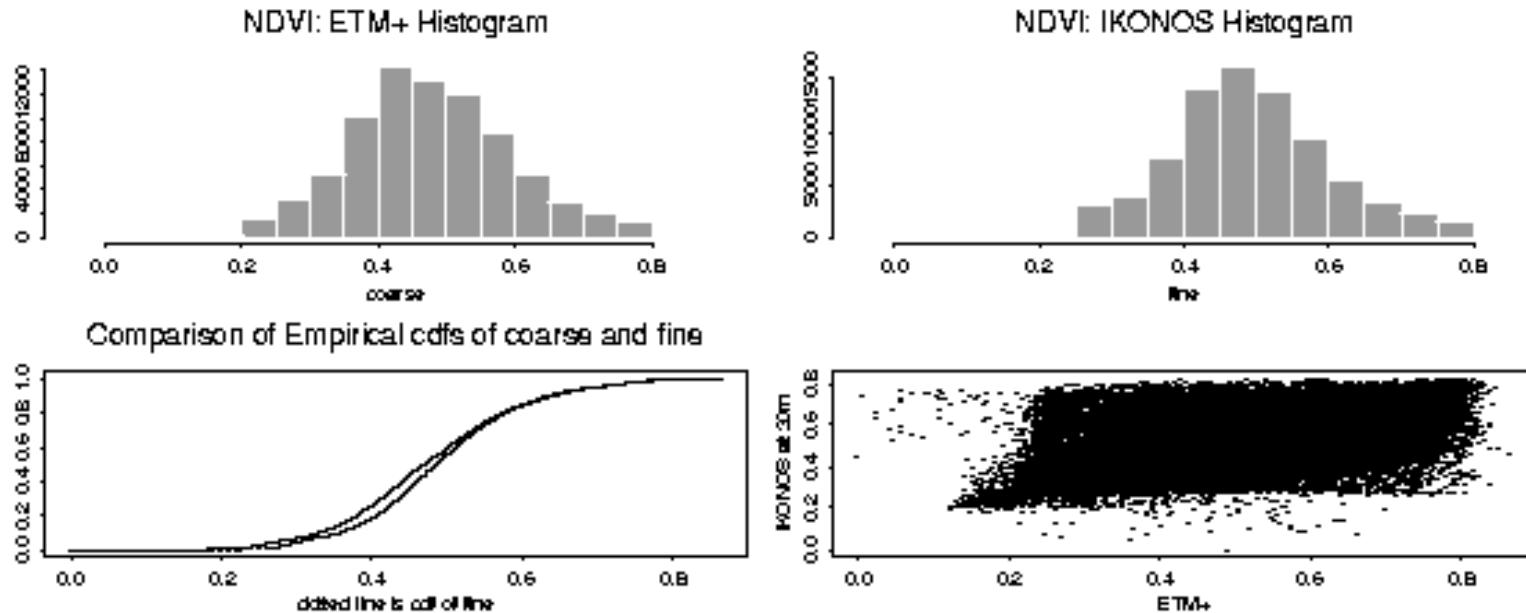
ETM+,
Sept. 11

IKONOS,
Sept. 15

Aeronet sun photometer (Meyer)
Vermote et al.'s Six S code
(for ETM+ and IKONOS)



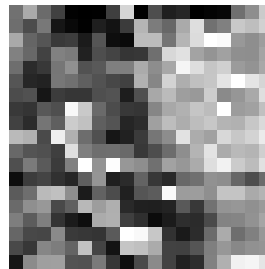
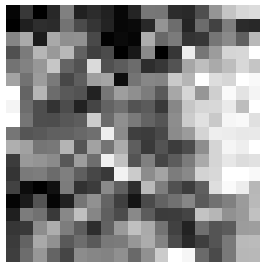
IKONOS vs ETM+: Normalized Difference Vegetation index (NDVI)



Correlation = .5639

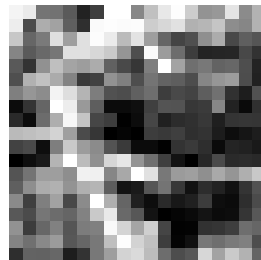
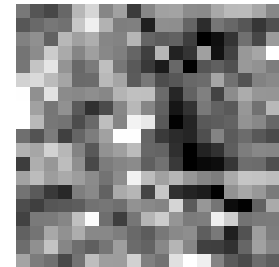


Normalized differences: method to include variability



$$\frac{\text{ETM+} - \text{IKONOS(average)}}{\text{Std. Dev (IKONOS ave.)}}$$

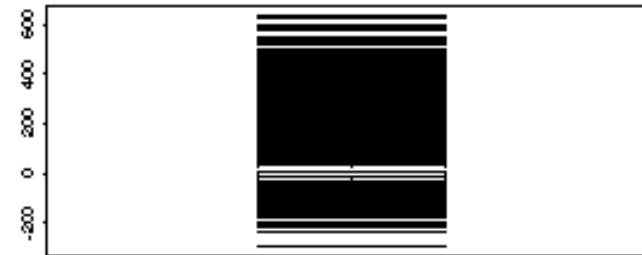
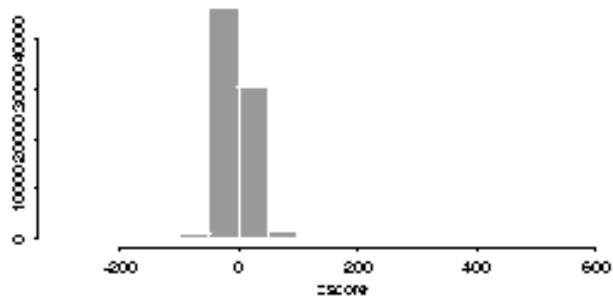
= "z score"



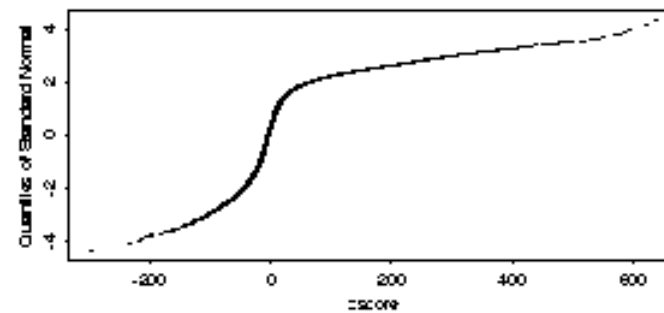


Z score analysis: ETM+ vs IKONOS

Z Score Histogram: IKONOS vs ETM+



Empirical and Hypothesized normal CDFs



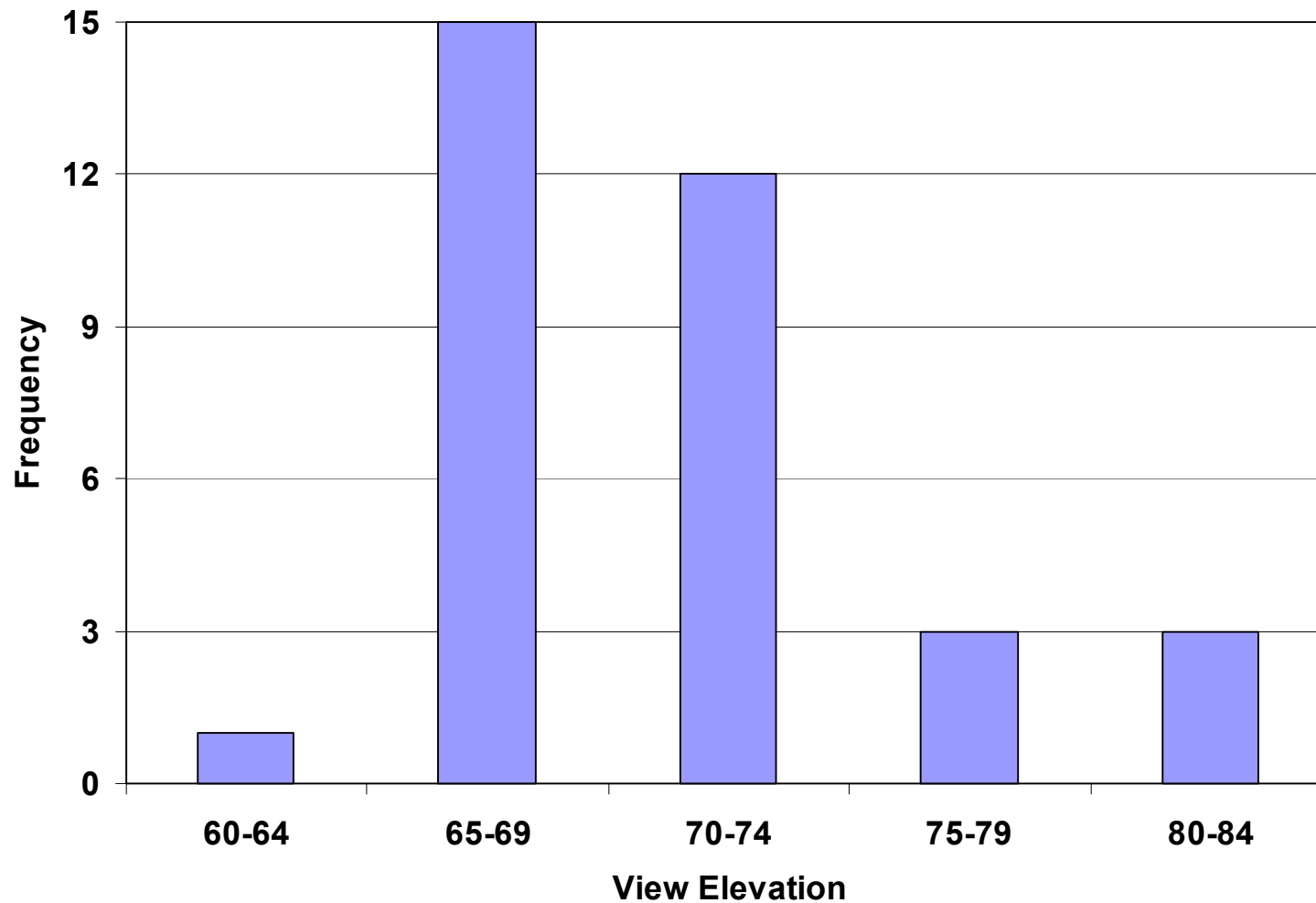
IKONOS vs ETM

[illegible]



View elevation angle distribution

34 related acquisitions to-date





Conclusions

- **IKONOS is proving useful as a bridging between field and ETM+ (ASTER) imagery**
- **Globally consistent data is useful for globally representative validation (i.e. Core Site data suite)**
- **Solid coordination with Stennis Scientific Data Purchase and Space Imaging**
- **Infrastructure of MODLAND Validation has helped maximize use of IKONOS scenes**
- **Radiometric issues need to be resolved for validation activities that utilize radiometric information**
- **Related publication are forthcoming: MODLAND special issue of Remote Sensing of Environment, SI “Imaging Notes” article, and potential special issue on Land Product Validation**

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